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Software Description

UrbanAnts: An R Shiny app for exploring ant diversity data in urban environments

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Abstract

With the advance of urbanisation and the challenges associated with the process of documenting new species, biodiversity is increasingly threatened, especially in urban areas, where species are more exposed to the negative effects of landscape transformation. In this context, databases are fundamental tools for documenting, monitoring and conserving biological diversity. Within this scope, UrbanAnts was developed as a web application designed to centralise information on ant diversity and occurrences in urban environments. The platform was created using the Shiny framework, built on the R programming language and integrated with a relational SQLite database. UrbanAnts improves accessibility and streamlines data exploration, enabling users to efficiently retrieve and analyse information. In addition, it serves as a tool that highlights the importance of conserving the diversity of ant fauna in urban environments. This database is accessible to the public through the dissemination of knowledge and the encouragement of participation, allowing contributions from both professionals who study ants and members of the general public interested in collaborating through citizen science.

OPEN ACCESS

Key words: Anthropogenic habitat ecology, biodiversity, biological data repository, data-driven conservation, Formicidae, fauna monitoring, species occurrence records

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Introduction

Natural ecosystems are increasingly being impacted by climate change, habitat fragmentation and degradation, pollution of soil, water and air and the overexploitation of natural resources (Jaureguiberry et al. 2022; Montràs-Janer et al. 2024). These impacts are further exacerbated by the introduction of exotic species and the intensification of land use, compromising ecosystem services (Daskalova et al. 2020; Adla et al. 2022; Pereira et al. 2024). As anthropogenic processes intensify, monitoring biodiversity becomes increasingly challenging (IPBES 2019). This scenario is particularly concerning because a significant portion of global biodiversity remains unknown (Anthony et al. 2023), with many species at risk of disappearing before they are discovered and described, resulting in irreversible losses to both science and ecosystems (Borgelt et al. 2022).

Thus, integrating knowledge about the biodiversity of these environments is essential to support actions that ensure a sustainable future (Heberling et al. 2021).

The ability to identify and recognise the species within a local community or region plays a vital role in addressing the challenges of biodiversity loss (Godfray et al. 2004). By increasing public knowledge of species, we can foster broader recognition of nature's importance, raise awareness of threats posed by human activities and promote the adoption of conservation strategies (Knapp et al. 2021). Understanding the distribution and diversity of organisms depends on the availability of large, standardised, robust and comprehensive biological datasets. In this regard, databases serve as key tools for species documentation and conservation (Porter 2000; Baxevanis and Bateman 2015). However, the challenges are immense, as biological information is often unavailable or fragmented across multiple datasets, making it difficult to compile and compare trait information between different groups.

Over the years, researchers have gathered extensive information on ant diversity, resulting in hundreds or even thousands of records for various species across different ecosystems, although these records are not always stored in databases (Feitosa et al. 2022; Schmidt et al. 2022). In the case of ant fauna, information can be found in several sources, including: (I) the Global Ant Biodiversity Informatics (GABI) Project, a global database of ant species distribution records linked to www.antmaps.org (Guénard et al. 2012); (II) GlobalAnts (www.globalants.org), which compiles data on functional characteristics with associated set-level georeferenced data (abundance and/or occupancy) of ant specimens (Parr et al. 2017); (III) AntWeb (www.antweb.org), the largest online database of high-resolution images and specimen records; (IV) AntCat (Bolton (2025): www.antcat.org), a comprehensive catalogue and bibliography of ant taxonomy worldwide; and (V) the Atlantic Ants dataset (Silva et al. 2022), which presents the diversity of ants in the Atlantic Forest in an extensive, validated and georeferenced dataset.

A gap remains in knowledge about the diversity of ants in urban environments, particularly those that co-exist with humans, inhabiting both the interiors of buildings and their surrounding areas, even with the availability of these databases. Urban ants are closely associated with humans and are commonly characterised as unicolonial and polygynous, possessing long-lived queens that, in most cases, forego nuptial flights (Passera 1994). In addition, their nests are poorly structured and the workers are small [e.g. little fire ant, *Wasmannia auropunctata* (Roger, 1863); longhorn crazy ant, *Paratrechina longicornis* (Latreille, 1802); and Argentine ant, *Linepithema humile* (Mayr, 1868)], with high interspecific aggressiveness and migratory tendencies (Passera 1994; Bueno et al. 2017; Campos et al. 2017). However, species that do not have these characteristics are also found in urban environments, such as native species that use urban green areas as refuges due to changes in their natural habitats and exotic species that disperse and establish themselves in these areas driven by urbanisation (Bueno et al. 2017; Trigos-Peral and Reyes-López 2025).

In this study, we present UrbanAnts, a database developed using the Shiny framework, aimed at guiding the recording of ant species occurrences in urban environments. The objectives are to: (I) integrate and compile data on ants occurring in urban environments, unifying existing and newly-collected records into a single validated source of information; (II) encourage the active participation of researchers in data collection and validation, as well as public engagement and

inclusion through citizen science; (III) develop a standardised and user-friendly protocol for data submission; (IV) raise awareness about the ecological importance of ants in urban environments, promoting their use as a tool for public policies related to conservation, sustainable management and environmental education; and (V) establish mechanisms for the continuous updating and expansion of the database, ensuring its longevity and relevance for the future.

Introduction to the database and its user interface

UrbanAnts (https://urbanants.shinyapps.io/UrbanAnts/) was developed using Shiny (Chang et al. 2024; version 1.10.0), an R-language framework (Posit Team 2024; version 12.0.467) for building web applications. Both the platform and its content are openly accessible to users. Its main objective is to provide, simply and intuitively, a comprehensive database on ant diversity in urban environments. The database consists of a structured collection of data, organised and managed through a specific database management system (DBMS). In this implementation, the data are stored in an SQLite relational database, which ensures efficient retrieval, querying and maintenance.

With optimised features, the UrbanAnts platform allows users to explore information, view details and access specific content, such as records of species in urban environments, books and articles on the subject, data on project collaborators and relevant news and events.

The application is open access under a Creative Commons Attribution licence (CC BY 4.0, https://creativecommons.org/licenses/by/4.0), allowing anyone to use and distribute data collected on UrbanAnts, provided that the database and contributing datasets are properly cited.

The web app follows a panel-based design consisting of a header, a sidebar menu and the main page (Fig. 1). The panel header is located at the top of the interface and displays the app's name (UrbanAnts) and logo, along with a side menu. The sidebar menu, positioned on the left, enables easy navigation through all available features.

UrbanAnts functionalities

Currently, UrbanAnts is available in Brazilian Portuguese, facilitating the dissemination of content to the citizen-science community in Brazil. This choice ensures that local volunteers, students and researchers can easily access and engage with the information.

Nonetheless, we aim to develop a bilingual version (Portuguese–English) of the platform to broaden its reach and improve accessibility for international researchers and collaborators. Users can employ automatic translation tools provided by modern web browsers (such as Google Chrome or Microsoft Edge) to view the content in their preferred language, while the bilingual interface is still under development.

The app's features are displayed in the side menu (Fig. 2). The *Página Inicial* [Home Page] provides an overview of the application's purpose and available functionalities. The *Mapas das Áreas* [Area Map] feature enables users to explore the geographic locations of each area on the map, where the database contains records of ant species.

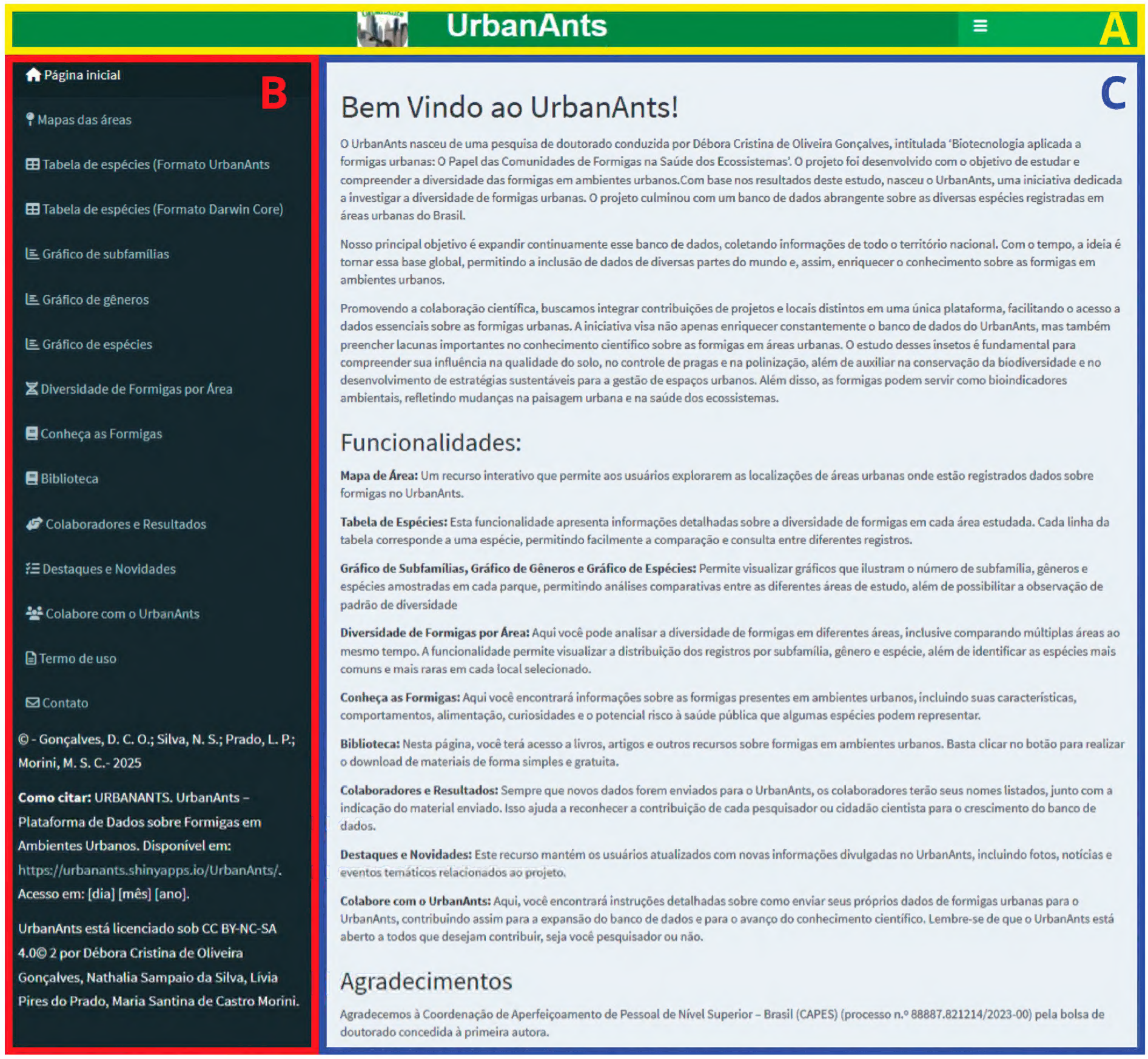

Figure 1. Home interface of the UrbanAnts platform. The figure presents the layout of the main interface of the UrbanAnts web application, composed of three primary components: (**A**) a header containing the logo and the application name; (**B**) a sidebar menu used to navigate through the platform's main features; and (**C**) the main content area, which displays detailed information related to each feature selected from the sidebar.

The *Tabela de Espécies* (*Modelo UrbanAnts*) [Species Table (UrbanAnts model)] and the *Tabela de Espécies* (*Modelo Darwin Core*) [Species Table (Darwin Core model)] provide detailed information on ant diversity in each area. Each row corresponds to a species and is structured to facilitate consultation and comparison across different records. Both tables contain all occurrence data available in UrbanAnts, but are presented in different formats. The Species Table (UrbanAnts model) offers comprehensive data on specimen occurrences, including precise location, collection method, collector, date of collection, caste/sex/stage (major worker, minor worker, queen, winged and/or immature), abundance and data source, indicating the origin and authorship of the information. The Species Table (Darwin Core model) also presents this information, but follows an internationally recognised and widely adopted standard

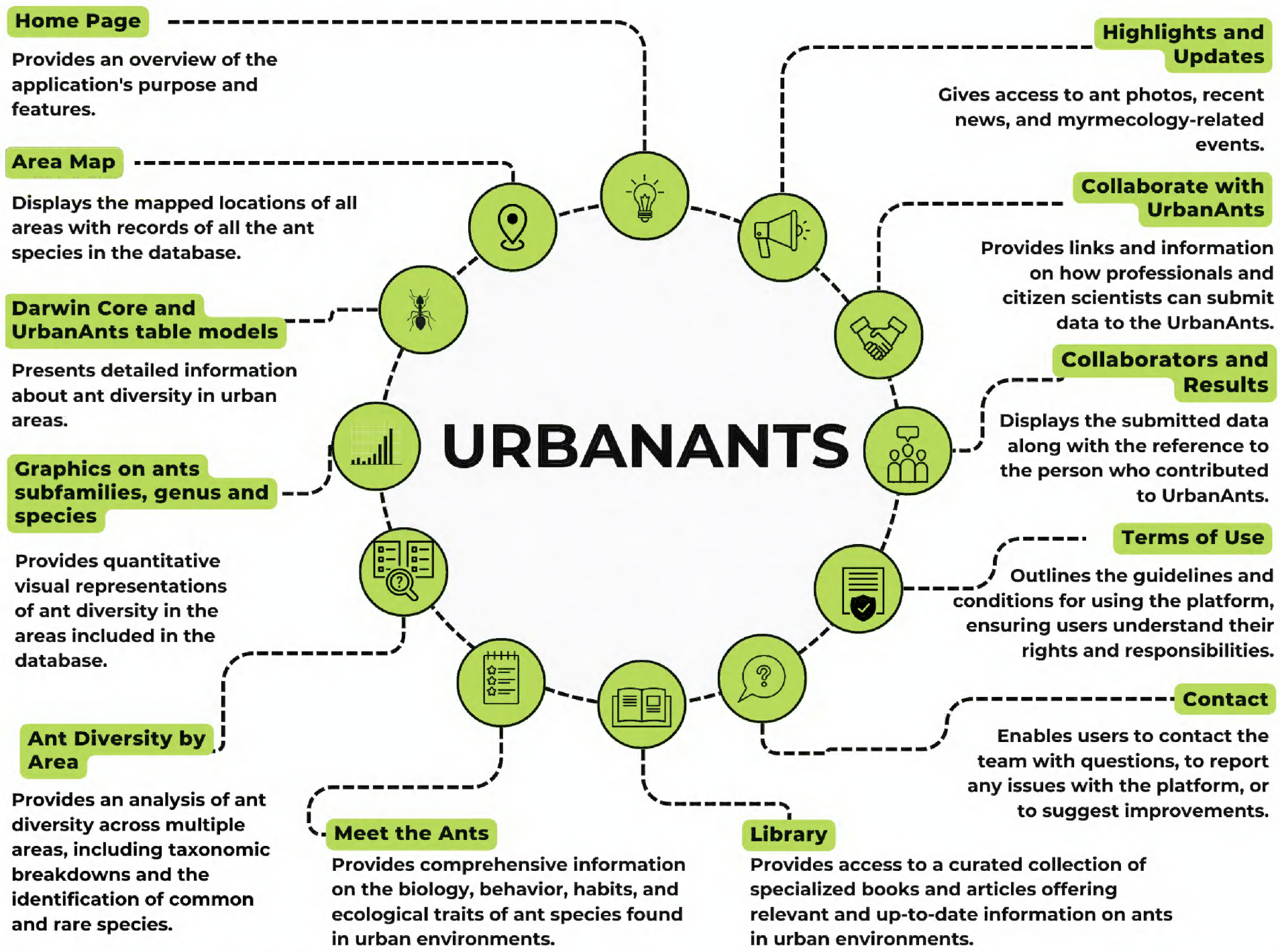

Figure 2. Overview of the UrbanAnts platform and its key features. This schematic diagram illustrates the structure and core functionalities of the UrbanAnts platform. At the centre of the figure is the application name, representing its integrative role. Surrounding it are the main tools and components that define the platform's functionality.

for biodiversity data sharing. Its standardised structure ensures broad compatibility with global systems, enhancing data integration, visibility and reusability by researchers, environmental managers, educators, policy-makers and collaborative networks in science, conservation and environmental monitoring.

The *Gráfico de Subfamílias* (Subfamily Graph), *Gráfico de Gêneros* (Genus Graph) and *Gráfico de Espécies* (Species Graph) features provide quantitative visual representations of ant diversity in the areas covered by the database. The application extracts data from the species tables, accounting for the occurrences of each category (subfamilies, genera and species). The respective abundance values are also included for species. These data are processed and organised to generate bar graphs, providing a clear and accurate visualisation of the information. Additionally, below the species chart, UrbanAnts provides detailed biodiversity metrics for each area, including species abundance, species richness, Shannon diversity index, Pielou's evenness and Margalef's richness index.

The *Diversidade de Formigas por Área* (Ant Diversity by Area) feature allows users to analyse the distribution of ants across subfamily, genus and species levels, as well as to identify the most common and rarest species in the selected areas. Users can compare all areas available in the database or focus on those of specific interest.

The *Conheça as Formigas* (Meet the Ants) feature provides information about ant species found in urban environments, including details on their behaviour, feeding habits, biological and ecological curiosities and their importance to the environment.

In the *Biblioteca* (Library) tab, users can freely access a variety of books and articles specialised in the subject, ensuring that relevant and up-to-date content is readily available. In *Destaques e Novidades* (Highlights and Updates), users can view photos, stay informed with the latest news and keep track of events related to myrmecology.

The *Colabore com o UrbanAnts* (Collaborate with UrbanAnts) and *Colaboradores e Resultados* (Collaborators and Results) features were designed to facilitate and promote the expansion of the database. In Collaborate with UrbanAnts, we invite researchers studying ants in urban areas, as well as the general public, to contribute to the database. The goal is to unite efforts through citizen science, fostering collaboration between experts and engaged citizens.

Through this initiative, researchers can share their data in a structured way, expanding the reach and impact of their findings. At the same time, the public can actively participate in data collection, promoting greater awareness of urban biodiversity and contributing to scientific progress.

The platform provides a standardised table that can be directly downloaded via a link, along with clear instructions for submitting data. In addition, for citizen-science initiatives, participants can submit extra information through our form, such as photos, descriptions and relevant observations about ants in urban environments.

The menu also includes a *Termos de Uso* (Terms of Use) section, which outlines the guidelines and conditions for using the platform, ensuring that users understand their rights and responsibilities when accessing UrbanAnts. Additionally, we provide a *Contato* (Contact) tab, where users can reach out to clarify any questions about the platform, report potential issues or submit suggestions for improvement.

Initial data

The database was initially developed as part of the first author's (DCdeOG) doctoral research on ant diversity in urban areas. Preliminary data were collected in São Paulo, Brazil's largest metropolis and one of the most populous cities in the world (IBGE 2023). The data were collected from eight parks in São Paulo, SP, Brazil (Parque Alfredo Volpi, Parque Anhanguera, Parque Previdência, Parque do Carmo – Olavo Egydio Setúbal, Parque Ecológico Chico Mendes, Parque Ibirapuera, Parque Jardim da Luz and Parque Tenente Siqueira Campos – Trianon). These records document ant diversity in these environments and include data on country, state, locality, latitude and longitude, collection date, collection method, collector, subfamily, genus, species and counts of major and minor workers, queens, males, immature stages and general species abundance. The database was initially formed by 10,346 data entries, totalling 85,859 individual occurrence records.

Long-term development

The main objective of UrbanAnts will be to expand its database by collecting and organising comprehensive information on ant species inhabiting urban areas in all regions of Brazil. This initiative will include records from a wide

range of urban environments, such as residential, commercial, industrial, hospital, institutional, recreational, cultural, natural, historical, port and tourist areas.

We currently have a dedicated moderation team responsible for reviewing and organising the data submitted to the UrbanAnts platform. This team ensures that all records meet quality standards and align with the project's scientific goals. As the platform evolves and the volume of contributions increases, we intend to expand this team and engage a broader network of collaborators, including researchers, students and citizen scientists. This collaborative approach aims to strengthen data validation, foster community involvement and ensure the scientific rigour and long-term sustainability of the database.

Simultaneously, UrbanAnts will foster scientific collaboration with research groups across the country to consolidate diverse datasets into a unified, integrative repository. We will incorporate data extracted from previously published studies and organise species lists and associated occurrence records using standardised templates to support this goal. All incorporated data will be properly referenced and cited, ensuring visibility, reproducibility and alignment with global data-sharing practices.

We will also actively encourage researchers and institutions to contribute original and unpublished data. All submissions will undergo a rigorous scientific validation process to ensure accurate species identification, reliable occurrence records and ecological relevance. This validation will be conducted by myrmecology experts, who will examine physical specimens deposited in museum collections whenever possible, review associated media, such as photographs and videos, consult relevant literature and participate in discussions with other researchers. This comprehensive protocol will safeguard the scientific integrity of the database and maintain the platform's consistency and credibility. Once validated, records will be published with full citations, ensuring traceability and proper acknowledgment of contributors' authorship.

Citizen science will be a central component of UrbanAnts. The project will invite public participation through the submission of photographs and videos of ants observed in urban environments. Contributors will receive guidance and support from the UrbanAnts team to ensure complete, high-quality submissions. Contributors will be notified after validation and their records will be published on the platform with full attribution. This ongoing interaction will strengthen public engagement and raise awareness of urban biodiversity, which is often overlooked or underestimated.

We at UrbanAnts are committed to maintaining an increasingly dynamic platform, continuously evolving and aligned with the needs and contributions of its users. Continuous improvement will be driven by community feedback and technological innovation. We will develop interactive tools to enhance data visualisation, including species-level mapping and improve the accessibility and usability of the web interface. New features will be implemented to foster deeper user engagement.

In addition, UrbanAnts will pursue collaborative partnerships with research institutions, educational organisations and biodiversity-focused initiatives. These partnerships will support the development of new tools, including mobile apps, plugins and integrations with other biodiversity databases. We will also expand the geographic scope of the database to include records not only from Brazil, but from around the world. The platform will be available in English to support this international expansion. This global approach will enrich the platform's ability to reflect the diversity and distribution patterns of ant species in urban landscapes, both in Brazil and internationally.

Conclusion

The UrbanAnts application is the first initiative in its category, a database dedicated exclusively to compiling information on ant diversity in urban environments. It is designed to consolidate data in an intuitive, efficient and accessible way, centralised in one location and available online. UrbanAnts represents an unprecedented advance in integrating data on ant occurrences in urban environments, promoting citizen science and providing valuable resources for both researchers and the general public. Initially, UrbanAnts provides occurrence data from eight urban areas. New areas will be added as expansion and utilisation progress and analytical tools will be enhanced to improve data visualisation and interpretation. In addition to advancing knowledge about urban biodiversity, UrbanAnts serves as a tool to support public policies on the conservation, sustainable management and control of species in urbanised areas. The application also enables a better understanding of the distribution, natural history, ecological roles and interactions of ants within urban environments. By integrating data from multiple contexts, the platform fosters interdisciplinary research across diverse fields of knowledge throughout Brazil, a country recognised for hosting one of the highest levels of ant biodiversity in the world.

Technical specifications

Platform: Shiny, R
Programming language: R
Operating system: Windows, OSx, Linux
Interface language: shiny-dashboard

Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Use of AI

No use of AI was reported.

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Author contributions

Conceptualization: DCCOOG, NSS. Data curation: DCCOOG. Methodology: LPP, NSS. Software: DCCOOG. Supervision: MSCM. Validation: MSCM, NSS, LPP. Writing - original draft: DCCOOG. Writing - review and editing: NSS, LPP, MSCM.

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Data availability

All of the data that support the findings of this study are available in the main text.

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